



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

ii. Objectives of the module: The problem-solving strategy titled "Guess and Test" is a process that consists of at least the following steps:

1. Make a guess.
2. Check the guess.
3. Use the first guess to make a better guess.
4. Repeat 1-3.

This strategy was selected by MPSP as the first one to use for testing the feasibility of developing instructional materials to teach problem-solving strategies. The process given above is not described in the teachers' booklet. In an attempt to determine whether this process was evident in the module, the Trial II teachers were asked during individual interviews (1) what they perceived to be the objective of the module and (2) if the materials were congruent with that objective.

Most of the teachers identified the objective of the module to be a process similar to the one given above. These same teachers also felt that the process was present in the instructional booklet. However, they did feel it was necessary to identify that process for the students and continually reinforce its use throughout the experiences with the problem deck.

iii. Problem card selections. Tables 12, 13, and 14 were developed for the purpose of identifying trends in the problem card selections. The following observations seem most salient with respect to the selections.

Table 12

1. The multiple-condition problems (V) were attempted least in both trials among the four problem types.

2. The green multiple-condition problems (V) were attempted least in both trials among the four problem types at each level of difficulty.
3. The diagram (D) and measurement (M) problems were attempted most frequently in both trials. The measurement problems in Trial I were attempted a much greater number of times than the other problem types. This is interesting since the measurement lesson was the least popular one according to teacher reports.

Table 13

4. For both trials the percent of the total number of problems attempted for each problem type is very close to the percent of the total problems available in the deck of that type.
5. Nearly half of the problems attempted during Trial I are at the blue- (easiest) level of difficulty.

Table 14

6. For Trial I, as the level of difficulty increases, the percent of the problems rated hard increases. For Trial II, the white problems were rated the most difficult. When the results for both trials are combined, the green problems were rated the hardest followed by the white cards, not the red ones as one would expect.
7. The Trial I students rated a higher percentage of the problems "hard," than did the Trial II students. This observation in Table 14 is supported by the verbal feedback from the teachers that the problems in the deck seemed difficult for the students. The teachers in Trial II did not mention that the problems in the deck appeared to be too difficult for the students. The numbers of teachers at each grade level were very similar for both trials.
8. The percentages of problems rated as "liked" for each problem type are nearly the same.

The data in this section related to the organization and content of the module was grouped into three categories: (1) editorial changes, (2) objectives of the module, and (3) problem card selections. The data analysis in this section suggests the following recommendations/comments related to the organization and content of the module (specifically, the one used for the second trial).

Instructional Booklet

1. A discussion concerning the role of "Guess and Test" in problem solving should be included in the teacher's booklet or premodule activities.
2. The "overview" of each lesson should relate the objective of that lesson to the overall objective, i.e., the "Guess and Test" strategy.
3. It appears that the teachers that used this module were able to identify for the most part the "Guess and Test" process in the booklet. Those same teachers mentioned that they found it necessary to continually review that process while the students were solving the problems in the deck. Since all the teachers did not identify this process, a detailed discussion of the "Guess and Test" strategy should be included. This recommendation is closely related to number one.
4. Nearly all of the teachers were satisfied with the content and format of the booklet.
5. The teacher's notes were quite appropriate for the teachers in

Trial II.

Problem Deck

6. The alphameric code on the problem cards should be explained in the teacher's booklet.

Table 12

Total Number of Problems Attempted by Students
at Each Level of Difficulty and Problem Type

Trial I (N=5 classes) ^a					
Difficulty Level	Problem Type				Total
	C	D	M	V	
blue	229(4) ^a	367(6)	473(9)	208(4)	1277(23)
yellow	114(9)	84(6)	180(8)	147(8)	525(3)
white	132(10)	110(8)	127(8)	64(5)	433(31)
red	92(9)	63(8)	98(9)	64(6)	317(32)
green	66(7)	42(5)	71(7)	36(5)	215(24)
Total	633(41)	666(38)	949(33)	519(28)	2767(133)
Trial II (N=5 classes) ^b					
blue	97(4)	218(6)	204(9)	58(4)	577(23)
yellow	79(9)	107(6)	106(8)	90(8)	382(31)
white	133(10)	49(8)	73(8)	46(5)	301(31)
red	68(9)	82(8)	79(9)	89(6)	318(32)
green	25(7)	59(5)	28(7)	12(5)	124(24)
Total	402(41)	515(39)	490(33)	295(28)	1702(133)

^a Total number of problems available at each level.

^b Half of all the data for one class in Trial II was lost for that Trial.

Table 13
Percent of Total Number of Problems Attempted
for Each Difficulty Level and Problem Type

Trial I					
Difficulty Level	Problem Type				Total
	C	D	M	V	
blue	8(2) ^a	13(5)	17(7)	8(3)	46(17)
yellow	4(7)	3(5)	7(6)	5(6)	19(24)
white	5(8)	4(6)	5(6)	2(4)	16(24)
red	3(7)	2(6)	4(7)	2(5)	11(25)
green	2(5)	2(4)	3(5)	1(4)	8(18)
Total	22(29)	24(26)	36(31)	18(22)	100(108) ^b
Trial II					
blue	6(2)	13(5)	12(7)	3(3)	34(17)
yellow	5(7)	6(5)	6(6)	5(6)	22(24)
white	8(8)	3(6)	4(6)	3(8)	18(24)
red	4(7)	5(6)	5(7)	5(5)	19(25)
green	1(5)	3(4)	2(5)	1(4)	7(18)
Total	24(29)	30(26)	29(31)	17(22)	100(108)

^a Percent of total problems available at each level.

^b Greater than 100 due to rounding error.

Table 14
Percent of Problems Rated as Hard and Disliked
at Each Level of Difficulty and Problem Type

Trial I					
Difficulty Level	Problem Type				Total
	G	D	M	V	
blue	10,14 ^a	13,14	6,22	10,15	9,13
yellow	11,10	7,6	8,7	5,12	8,9
white	12,14	11,12	16,13	11,17	13,14
red	22,13	13,10	19,9	27,5	20,9
green	48,23	24,24	39,21	42,22	38,23
Total	21,15	14,13	18,14	19,14	18,14

Trial II					
blue	5,7	4,5	2,3	5,3	4,4
yellow	12,10	13,17	1,1	21,17	11,11
white	14,11	11,9	15,13	20,13	22,11
red	12,8	4,7	4,8	13,10	9,8
green	14,9	24,12	0,8	17,0	18,10
Total	11,9	9,9	4,5	15,10	11,8

Total					
blue	8,11	9,10	4,13	8,9	7,9
yellow	12,10	10,12	5,4	13,15	10,10
white	13,13	11,11	16,15	16,15	23,13
red	17,11	9,9	12,9	15,8	15,9
green	31,16	24,18	20,15	30,11	28,17
Total	16,12	12,12	11,10	17,12	15,11

^a The first number indicates the percent of students that indicated that problems in these categories were "hard", and the second number that they were "difficult". The percent rated "easy" and "liked" can be found by subtracting each of the numbers respectively from 100.

7. For each problem type, the percentages of problems rated as "liked" are nearly the same.
8. The specific difficulty ratings for the white problems should be considered. Overall, these problems were rated more difficult than the red problems.

c. Effectiveness:

i. Teacher judgment. This section of the report will be primarily concerned with the data from the module quizzes related to student performance. Student performance was assessed directly through module quizzes and indirectly through collective teacher judgment. During the in-service sessions and/or individual interviews the teachers were asked what they believed to be the most successful attributes of the module. The following comments are a selection of those received from Trials I and II.

Trial I

- It made students think about what they are reading and analyze their thoughts.
- The enthusiasm and willingness of the students to tackle problems.
- It made the students think.
- It gave the students a willingness to guess.
- Problem card format.

Trial II

- It made the kids think differently and realize there is frequently more than one solution to a problem.
- Format of the materials, that is, a booklet followed by a problem deck.
- Attitudinal gains.
- Interesting problems.
- Students of all ability levels found success with the module.

Clearly, most of the comments above are related to dimensions of effectiveness other than student performance. Some of the dimensions reflected in the above comments are (1) attitudes, (2) format of the materials, and (3) the appropriateness of the module for all ability levels.* It appears that the module may have had a positive effect on many different areas.

ii. Module quizzes. The module quizzes used for the evaluations were developed by the MPSP evaluation staff at Indiana with the assistance of one of the module developers from the University of Northern Iowa (UNI). For Trial I, six forms of a quiz were administered as a post-test only to 212 students that participated in the trial (experimental group) and 74 students that did not participate (control group). For Trial II, four forms of a quiz were administered as a pretest - post-test to 225 students. "Control" students were not used for Trial II.

Four separate analyses of the quiz results are included in this section. The quiz results were analyzed by objective and grade

level:

- (1) for both trials combined,
- (2) across trials,
- (3) for each trial separately,
- (4) with respect to the problem card selections.

A specific criterion level for successful performance was not established.

Rather, the quiz results were examined for any trends that suggested changes in the module.

* In the section on organization and content, it was mentioned that the Trial I teachers found the content of the module too difficult for low-ability students. In contrast, three teachers in Trial II (two fourth and one sixth) commented that the material was appropriate for all ability levels.

In each of the four analyses the fifth-grade classes generally scored lower than the fourth- and sixth-grade classes. Although this trend is present in the classes involved in both trials, it is most obvious in Trial I (see Tables 17, 18, and 19). In an attempt to identify a cause for this trend, the scores on the Stanford Achievement Test (SAT) for each class were analyzed.* Table 15 shows that the mean scores for:

- (1) the fourth- and fifth-grade classes are quite close for both trials while the sixth-grades scores are the highest.
- (2) Trial I, the mean SAT score for the fourth-graders (teachers 40, 13, & 23) is 43.5 and 43.7 for the fifth-graders.
- (3) Trial II, the mean SAT score for the fourth-graders is 50.0 and 58.0 for the fifth-graders.
- (4) Trial I, the mean SAT score for the seven teachers is 49.6 and, for Trial II, 65.6.

Table 15

Mean Adjusted SAT Scores for the Classes
Used in the Analyses of the Quizzes

Trial I			Trial II		
Teacher Number	Grade	Mean Adjusted SAT	Teacher Number	Grade	Mean Adjusted SAT
40	3/4	-- ^a	27	4	50
13	4	54			
23	3/4/5	31			
15	5	58	02	5	62
11	5	44	04	5	54
22	5	26			
26	6	62	21	6	72
14	6	72	20	6	90

^a Missing data.

* The SAT was administered at the beginning of the school year as one of the summative evaluation instruments of MPSP.

These four observations are reflected for the most part in the quiz results for the two trials. With regard to the first observation, the sixth grade performed the highest in Trial II but scored lower than the fourth-graders in Trial I (see Table 17). For observations two and three, Table 17 shows that the fifth-graders in Trial I scored lower than the fourth-graders by 15.2 percentage points* while the difference for Trial II is only 4.5 percentage points, and the fourth-grade means for both trials are nearly the same (50.5 for Trial I versus 54.9 for Trial II). Tables 17, 18, and 19 support the fourth observation in that the means for the Trial II classes are generally higher than the means from Trial I.

This analysis concerning the observed trend in the performance of the fifth-grade students does not directly contribute to suggestions for revising this module. However, the analysis does show that for these teachers the mean SAT scores for each grade appear to be reflected in the performance on the module quiz. Since one purpose for developing the module quiz was to construct an evaluative instrument to accompany the final version of the module, further analysis of a possible interaction between the SAT scores and the scores on the module quiz would contribute to establishing the validity of the module quiz. The activities required to carry out this recommendation were not performed by the MPSP evaluation staff due to the termination of the project.

For both trials combined, Table 16 shows that the mean percent of correct solutions on all forms of the module quiz for both trials is 51.0 percent.

* The fourth- and fifth-grade students were administered different tests for Trial I.

The highest performance was on the first objective related to "computation" (71.6%) and the lowest performance was on the last problem on the quiz (30.0%). On all except one form of the quiz the last problem is a multiple-condition problem. However, the type of multiple-condition problem that was selected for the last problems is similar to only eight of the 28 multiple-condition problems in the deck. Also, these eight problems were attempted a total of 250 times which is only six percent of the total attempts. On the other hand, the items used for objective two, multiple conditions, are similar to the majority of multiple-condition problems in the deck. These problems make up 27 percent of the total number of problems attempted. The performance related to objective two was somewhat higher (47.8%) than the performance on the last problems (30.0%).

Table 16
Quiz Results by Objective and Grade
Level for Both Trials Combined

Objective	Grade			Mean
	4 (N=171)	5 (N=136)	6 (N=126)	
Computation	75.6	67.0	72.3	71.6
Multiple Conditions	50.6	38.1	54.7	47.8
Diagrams	48.9	40.8	56.0	48.6
Measurement	54.2	53.5	62.8	56.8
Solve a Problem Using Guess and Test	36.8	27.5	25.8	30.0
Mean	53.2	45.3	54.3	51.0

Since the problems used for the last items on the quizzes are also, for the most part, multiple-condition problems, Table 16 shows that performance on all of the "multiple conditions" items was the lowest. The section of this report on organization and content (see Table 13) shows

that the multiple-condition problems were attempted the least number of times in both trials. The data in Table 16, together with the frequency of card selections, suggests that the number of cards attempted is reflected in the performance on the quiz. This point will be discussed later in this section.

Across Trials. Table 17 shows that the performance of the Trial students on the module quiz was higher than that of the Trial I students.

- each grade level collapsed across objectives,
- each objective collapsed across grade level, and
- thirteen of the fifteen means at each grade level and objective

Although many reasons may account for these trends, four possible reasons are: (1) the ability levels of the students, (2) the difficulty of the quizzes, (3) the effectiveness of the revised module, and (4) different teachers. An analysis of the mean SAT scores for the class in both trials shows that the mean for Trial II (65.6) is higher than the mean for Trial I (49.6) (see Table 15). The quizzes used in Trial II were developed by analyzing those used for Trial I. Therefore, it is doubtful that the difficulty level was any less for the forms used in Trial II. With regard to reasons three and four, it is clearly not possible to determine the exact contributions of these factors. In the light of teachers' comments discussed earlier, it seems reasonable to attribute some of the improvement in scores to the changes in the module.

For each trial separately. Tables 18 and 19 show the quiz result for each trial. For the most part, the trends observed in these tables are the same as those in Tables 16 and 17. The data in Tables 18 and 19 is best interpreted with respect to the problem card selections.

Table 17
Percent of Correct Answers on Quizzes Across
Trials and By Grade Level and Objective

Objective	Grade						Combined	
	4 Ia (N=93)	4 II (N=78)	5 I (N=65)	5 II (N=71)	6 I (N=54)	6 II (N=76)	Combined I (N=212)	Combined II (N=225)
C ^b	73.1	78.3	56.3	72.3	66.1	7	65.2	75.1
V	51.3	50.3	37.6	38.4	42.0	61	43.6	49.9
D	43.4	51.7	30.1	46.2	38.9	64.5	37.5	54.1
M	58.1	52.3	48.2	56.1	52.4	68.0	52.9	58.8
S	26.8	41.8	4.6	39.0	22.2	27.7	17.8	36.2
Mean	50.5	54.9	35.3	50.4	44.3	59.3	43.4	54.9

^a I - Trial One; II - Trial Two

^b C - Computation
V - Multiple Conditions
D - Diagram
M - Measurement
S - Solve a problem using guess and test

Problem card selections and quiz results. Table 18 shows the quiz results for Trial I at each grade level and objective. The following observations can be noted from Table 18:

- (1) The fifth-grade means are less than the fourth- and sixth-grade means for every objective.
- (2) For all but one objective at the fourth grade, the fourth- and sixth-grade experimental means are greater than the control means.
- (3) The mean for all grades is the lowest with respect to the problems where the student must attempt to find a solution and show his/her work.
- (4) The mean score for all grades and objectives is 43.4.

Observations 1, 3, and 4 are consistent with the trends previously discussed when the results for both trials were combined. Observation two

Table 18
Quiz Results by Objective and
Grade Level for Trial I

Objective	Grade			Total Mean (N=212 Exp.) (N=74 Con.)
	4 (N=93 Exp.) (N=13 Con.)	5 (N=65 Exp.) (N=48 Con.)	6 (N=54 Exp.) (N=13 Con.)	
V	73.1(74.6) ^a 51.3(48.0)	56.3(66.4) 47.5(34.7)	66.1(59.5) 42.0(37.3)	65.2(65.8) 43.6(39.3)
D	43.4(35.3)	30.1(34.3)	38.9(35.7)	37.5(36.2)
M	58.1(53.2)	48.2(47.4)	52.4(35.5)	52.9(45.4)
S	26.8 ^b (8.4) 43.5(--) ^c	4.6(18.2) 34.2(30.7)	22.2(15.5) 46.3(44.1)	17.9(14.0) 41.3(37.9)
	50.4(70.2)	59.8(49.0)	31.5(40.5)	47.2(53.2)
Mean	50.5(43.5) ^d	35.3(39.6)	44.3(36.7)	43.4(39.9)

^a The number in parentheses indicates the mean percent of correct solutions for the control students.

^b The first number is the mean percent of correct answers, the second is the mean percent of responses that maintained some of the conditions, and the third is the mean percent of responses that did not maintain any of the conditions in the problem.

^c This item was not a multiple-condition problem.

^d The mean percent of correct responses on the last item was used to calculate this mean.

is interesting. Even though the mean performance for the fourth and sixth-graders is less than 50 percent, the experimental students performed better than the control students.

Table 19 shows the quiz results at each grade level and objective for Trial II plus the mean gain in percent from the pretest to post-test. The following observations seem most relevant from this table.

- (1) There were gains from pretest to post-test for each grade and each objective with the exception of the 5th grade with objective C.

- (2) The fifth-grade means are less than the fourth- and sixth-grade means for most of the objectives.
- (3) The mean percent of correct answers for solving problems using guess and test is lowest for grades four and six and next to the lowest in grade five.
- (4) For grades four and six, the greatest gain was for the "diagram" problems.
- (5) For grade five, the greatest gain was on the item where they had to solve the problem(s).
- (6) The least gain was for the multiple condition items at grades four and five and for the correct solution to the "solve a problem..." items at grade six.
- (7) The highest mean at each grade level is for the "computation" items.
- (8) The mean performance for all grades and forms of the quiz ranges from 48.9 to 59.3 percent.

The data in Table 20 suggests that for Trial I, there is not a strong relationship between the average total number of problems attempted by each student and performance on the quiz, nor between the total amount of time spent with the deck and performance on the quiz. Also, a strong relationship does not appear to exist between the average number of problems attempted by each student at each level of difficulty and performance on the quiz.

* A rank-order correlation coefficient was used to suggest trends in the data.

Table 19
Percent of Correct Answers by
Grade, Form, and Objective

Fourth Grade						
Objective	Form 4 (N=38)		Form C (N=40)		Mean ^a	
	Post-Test	Gain	Post-Test	Gain	Post-Test	Gain
C	83.3 ^b	13.3	73.3	8.8	88.3	11.1
V	45.6	1.4	55.0	6.6	50.3	4.0
D	49.1	20.1	54.2	17.2	43.4	31.8
M	58.8	12.9	45.8	3.3	58.1	8.1
S	21.1	8.6	62.5	11.9	26.8	10.3
Mean	51.6	11.3	58.2	9.6	51.4	13.1
Fifth Grade						
Objective	Form 5 (N=35)		Form C (N=40)		Mean	
	Post-Test	Gain	Post-Test	Gain	Post-Test	Gain
C	77.1	2.8	67.5	-6.5	72.3	-3.7
V	34.3	6.7	42.5	-4.7	38.4	1.0
D	39.0	23.8	53.3	11.7	46.2	17.8
M	51.4	4.8	60.8	9.9	56.1	7.4
S	42.9	34.3	35.0	25.4	39.0	31.9
Mean	48.9	14.5	51.8	8.0	50.4	10.9
Sixth Grade						
Objective	Form 6 (N=38)		Form C (N=38)		Mean	
	Post-Test	Gain	Post-Test	Gain	Post-Test	Gain
C	73.7	7.0	77.2	8.8	75.5	7.9
V	63.2	10.5	58.8	6.6	61.0	8.6
D	58.8	19.3	70.2	17.2	64.5	18.3
M	72.8	8.8	63.2	3.3	68.0	6.1
S	10.0	-5.3	55.3	11.9	27.7	3.3
Mean	53.7	8.1	64.9	9.6	59.3	8.8

^a Forms C and 4 combined

^b Mean percent of correct solutions

Table 20
Problem Deck Use and
the Quiz Results

Trial I									
Class/ Teacher Number	Grade	Dif- f	B	W	R	G	Total	Total No. of Minutes Spent with Problem Deck	on the Post-Test Gain ^a
13	4	9 ^b	-	-	-	-	9	450	53.4
11	5	6	2	3	2	2	15	210	32.8
15	5	18	11	6	5	3	44	-- ^c	47.1
22	5	13	8	7	5	2	35	275	26.9
14	6	4	0	2	1	1	8	180	42.3
Mean		10.5	5	5	3	2	25	279	40.5
Trial II									
27	4	4	3	2	1	1	11	60	65.1, 31.7
02	5	9	5	2	1	0	17	120	57.1, 3.
04	5	4	2	3	2	1	12	180	51.3, 9.
21	5/6	-ac	-	-	-	-	--	---	-----
20	6	3	3	5	7	2	20	360	79.0, 13.
Mean		5	3	3	3	1	15	180	63.0, 14.4

^a A post-test only was used for Trial I.

^b Average number of problems attempted by each student rounded to the nearest whole number.

^c Missing data.

For Trial II, the data in Table 20 suggests some relationship between the performance on the quiz and (a) the average total number of problems attempted and (b) the average number of problems attempted at each level of difficulty. Also, some relationship appears to exist between the gain scores and the average number of problems attempted by each student at each level of difficulty.

iii. Summary of student performance on the module quiz. In this section the data from the module quiz for both trials of the module was analyzed. Also, a summary and discussion of the students' comments related to the usefulness of the module was presented. The results of the data analyzed in this section are summarized below and followed by recommendations related to possible revisions in the module.

1. The teacher feedback from both trials suggests that the module may have had a positive effect on many different areas (see p. 98).
2. In Trial I the experimental students outperformed the control students across objectives. In Trial II there were consistent pretest - post-test gains across objectives (with the exception of the fifth grade on objective C).
3. The fifth-grade mean scores in both trials generally are less than the means for the fourth and sixth grades. Some evidence was presented to suggest a possible interaction between scores on the Stanford Achievement Test and scores on the module quiz. For example, the fifth-grade students' SAT scores were generally lower than the SAT scores for the fourth- and sixth-grade students.
4. The mean percent of correct solutions on all trials was 51.0. The students in Trial II scored higher than the students in Trial I at nearly every objective and grade level. Four possible explanations were presented for the higher scores in Trial II (see p. 103).
5. The items in which the student must perform a computation to solve the problem (i.e., C-type problems) have the highest mean scores for all grades and objectives.

6. last problem of each quiz is one in which the student is asked to solve the problem and write his/her work on the quiz paper (compared to multiple choice for the remaining quiz items). Except for the fifth-grade students in Trial II, the mean scores on these problems were lower than all other mean scores.

7. In Trial II, the greatest gain score for the fourth and sixth grades is related to the "diagram" items.

8. Some relationship appears to exist for the classes in Trial II between the quiz performance and the average total number of problems attempted overall and at each level of difficulty. Also, some relationship was noted between the gain scores for the Trial II classes and the average number of problems attempted by each student at each level of difficulty.

iv. Recommendations. While the module appears to be generally effective and well received, there remain some considerations which bear further investigation.

1. Further analysis of a possible relationship between the SAT scores and the scores on the module quiz should be performed.
2. The higher performance of the experimental students compared to the control students in Trial I suggests that the students were better able to solve the items on the quiz as a result of experiencing the module, yet the mean score of correct answers for the experimental classes was only approximately 50 percent. The relatively low performance by all students can perhaps be attributed to (1) the difficulty of the module quiz and/or (2) the difficulty of the module.

3. The experiences with using diagrams to solve problems appear to have improved the students' ability to solve problems using diagrams. The large gain scores related to the "diagram" items in Trial II suggest that some consideration should be given to determining if there are any features of the lesson on diagrams which could be used to enhance other lessons.
4. Since some relationship was found between the average number of problems attempted at each level of difficulty and a class's gain scores on the module quiz, consideration should be given to a minimum number of problems that should be attempted at each level of difficulty.*

4. *Summary and Recommendations*

The module titled Using Guesses to Solve Problems was involved in two field tests during the 1975-76 school year in the Oakland Public Schools, Oakland County, Michigan. The first was from November 4 through December 16, 1975, and the second from February 18 through March 31, 1976. The formative evaluations of both trials were conducted under the general design of the formative evaluation given in Chapter A. Data was collected concerning the three major questions of the formative evaluations related to the implementation, organization and content, and effectiveness of the module. This section will summarize the results of the evaluation findings for both field tests related to each of the major questions.

a. Implementation:

1. The instructional booklet and problem deck were implemented in a variety of ways. Most of the teachers felt that the ability-grouping

* A discussion of this issue is included in the revised teacher's module developed as a result of this report.

procedures they selected and the amount of time spent on each lesson were appropriate for their students. The recommended teaching procedures (i.e., homogeneous teams of four and one class period per lesson) appear to be one way to implement the module but not the only way that can be successful. The teacher's booklet should mention that a variety of ways have been tried and have been found to be successful. Several of the ways that have been used to implement the booklet and problem deck could perhaps be described.

2. It appears that the module that was used for Trial II can be taught with one lesson per class period with most fourth-, fifth-, and sixth-grade students.
3. The teacher's booklet does not identify a recommended amount of time that the students should work in the problem deck. Even if there is not a recommended amount of time, some discussion of this point should be included in the teacher's booklet.*
4. Many of the students in Trial I solved problems sequentially in the deck, while most of the students in Trial II selected their own problems. Both procedures resulted in a decrease in the frequency of cards selected as the level of difficulty of the problems increased. This trend was expected.

b. Organization and Content:

1. A discussion concerning the role of "guess and test" in problem solving should be included in the teacher's booklet or premodule activities.*
2. The "overview" of each lesson should relate the objective of that lesson to the overall objective, i.e., the "guess and test" strategy.

* This issue is discussed in the revised teacher's booklet prepared as a result of this report.

3. It appears that the teachers that used this module are able to identify for the most part the "guess and test" process in the booklet. Those same teachers mentioned that they found it necessary to continually review that process while the students were solving the problems in the deck. Since all the teachers did not identify this process, a detailed discussion of the "guess and test" strategy should be included. This recommendation is closely related to number one.
4. Nearly all of the teachers were satisfied with the format of the booklet. Specific editorial recommendations are included in Appendix C.
5. The teacher's notes were quite appropriate for the teachers in Trial II.
6. The alphameric code on the problem cards should be explained in the teacher's booklet.*
7. Some consideration should be given to a recommendation that a minimum number of problems be solved in the deck and/or at each level of difficulty, in order to establish the likelihood of a minimum level of mastery. However, it is important to keep in mind that the problem deck was developed so that students at all ability levels could find some success with the problem deck; and, as a result, it may be unreasonable to identify some number of problems that should be attempted at each level of difficulty by all students.
8. For each problem type, the percentages of problems rated as "liked" are nearly the same.

* A discussion of the alphameric code is included in the revised teacher's module prepared as a result of this report.

9. The specific difficulty ratings for the white problems should be considered. Overall, these problems were rated more difficult than the red problems. However, most of the white problems were attempted by fifth-grade students, not sixth-grade students. The white problems may be most appropriate for sixth-grade students; and if so, this could be a reason why the white problems were rated more difficult than the red problems.

c. Effectiveness: The section related to the "effectiveness" of this module was primarily concerned with the students' performance on the module quiz. However, it was acknowledged that student performance is only one dimension of an effective instructional product. Many of the other dimensions of an effective instructional product are implicitly and explicitly identified in statements one through nine above. An analysis of the data included in the sections titled "implementation" and "organization and content" and the data related to the students' performance suggests that the module had a positive effect on students in several areas. Many of the summary comments and recommendations that are related to the effectiveness of the module have already been stated with reference to the implementation and organization and content. In addition, the following comments are related to the effectiveness of the module.

1. Further analysis of a possible interaction between the SAT scores and the scores on the module quiz should be performed.
2. The higher performance of the experimental students compared to the control students in Trial I suggests that the students were better able to solve the items on the quiz as a result of experiencing the module, yet the mean score of correct answers for the experimental classes was only approximately

50 percent. The relatively low performance by all students can perhaps be attributed to (1) the difficulty of the module quiz and/or (2) the difficulty of the module.

3. The experiences with using diagrams to solve problems appear to have improved the students' ability to solve problems using diagrams. The large gain scores related to the "diagram" items in Trial II suggest that some consideration should be given to determining if there are any features of the lesson on diagrams which could be used to enhance other lessons.
4. Since some relationship was found between the average number of problems attempted at each level of difficulty and a class's gain scores on the module quiz, consideration should be given to recommending that a minimum number of problems be attempted at each level of difficulty. However, it is important to keep in mind that the problem deck was developed so that students of all ability levels could find some success with the problem deck; and, as a result, it may be unreasonable to identify some number of problems that should be attempted at each level of difficulty by all students.

D. USING TABLES TO SOLVE PROBLEMS

1. Description of the Module

The module titled Using Tables to Solve Problems was involved in one trial during the 1975-76 school year in the Oakland Schools (February 18 through March 31, 1976). This is a report of the evaluation activities and findings of that trial.

The purpose of this module is to provide a sequence of experiences to introduce students to the use of tables in problem solving. The instructional booklet contains six lessons and the problem deck contains five levels of problem difficulty. The six lesson titles and the objectives of each lesson are:

1. Making a Table

Objective: Given a physical situation involving a numerical relationship, the students will place entries in a table that describes the numerical relationship.

2. Completing a Table

Objective: Given some entries in tables, the students will determine the relationship and complete the table.

3. Using Tables to Solve Problems

Objective: Given problem situations, the student will make tables to solve a series of related problems.

4. Using Tables to Solve More Problems

Objective: Given mathematical problems, the students will build tables and determine entries to solve the problems.

5. Reading Tables

Objective: Given a completed table, the student will be able to read the table to answer a list of questions.

6. Solving Problems

Objective: To acquaint students with the problem deck.

It is important to note that the purpose of this module is to intduce students to the use of tables in problem solving. This module was developed as part one of a two-module sequence on using tables to solve problems. Part two of the sequence has not been developed. As a result, the objectives of this module do not include all the objectives one might identify as relevant for using tables to solve problems.

Each card in the problem deck, in addition to being color-coded to indicate difficulty level, was coded with a letter to indicate the type of problem. Below are the letter codes and an example of each problem type.

C - "complete the table"

1BC1

COMPLETE THE TABLE.

Number of tricycles	5		20		
Number of wheels		30		24	300

Hint: Each tricycle has 3 wheels

S - "answer a sequence of questions"

5BS1

Hint: Every time you turn the handle 3 turns, the line goes down 5 feet.

Turns of Reel	3						
Feet	5						

1. The fish locator shows fish at 15 feet. How many turns of handle should I make to lower the bait 15 feet?
2. About how deep are you fishing when it takes 12 turns of the handle to raise the bait to the surface?

M - "make a table"

6BM1

MAKE A TABLE WITH 5 MORE ENTRIES TO SHOW THE NUMBERS OF WHEELS NEEDED.

Wagons	1	2					
Wheels	4	8					

Hint: Each wagon has 4 wheels.

B - "answer the bottom line question"

29BB1

A cartoon commercial runs at 24 frames per second. An artist has to draw a cartoon for each frame.

Seconds	1	2			
Frames	24	48			

How many cartoon drawings does an artist have to make for a 15-second commercial?

Hint: For 10 seconds you would need 240 drawings.

R - "read the table"

27BR1

AIRLINE MILEAGE CHART

	Chicago	Denver	Los Angeles	New York	San Francisco	Washington, D.C.
Chicago	X	901	1746	719	1847	617
Los Angeles	1746	849	X	2454	340	2286
New York	719	1617	2454	X	2566	200

How far is it between these cities:

1. Chicago to Denver?
2. Los Angeles to New York?
3. New York to Washington, D.C.?

Hint: Find the row for Chicago. Then read the number under Denver. That number is the distance in miles from Chicago to Denver.

Table 1 shows the number of cards of each type at each level of difficulty.

Table 1
Total Number of Problems of Each Type
at Each Level of Difficulty

	Type of Problem					Total
	C	S	M	B	R	
Blue (Easiest)	9	8	10	2	4	33
Yellow	10	6	9	3	6	34
White	6	12	1	6	12	37
Red	4	4	5	10	6	29
Green (Hardest)	6	6	3	5	3	23
Total	35	36	28	26	31	156

For each of the first five lessons the recommended "teaching procedure" was:

1. Discuss the opening scene (given in the booklet).
2. Guide the students as a whole class through two or three pages of the lesson.
3. Observe and listen to the students as they work in independent small groups on several pages of the module.

4. Give "optional problems" to groups who finish early. For lesson six, the teachers were to prepare the students to enter the problem deck by having them solve problems. In addition to these recommendations, the module developers suggested:

- one class period be spent on each lesson, and
- small groups of four students is the "best" way to organize the class for presenting the module.

2. Evaluation Design

a. General Design: The evaluation of the module was conducted under the general design of the formative evaluation given in Chapter A of this report. Data was collected related to the three major questions of the formative evaluations:

1. What implementation strategies are appropriate for the instructional modules?
2. Is the organization and content of the module appropriate for the intended population?
3. How effective is the module?

All instruments used to collect data and the number of classes in which the instrument was used are shown in Table 2.

Teacher comments concerning the booklet and problem deck were discussed as a group at the in-service session rather than written in the module. The evaluation staff did not decide to collect samples of student work for the formative evaluations until after the date the teachers had begun working with this module. Due to time constraints, classroom observations and written comments from the project staff were not collected. Also, the quiz was not available until the end of instruction.

b. Quiz: Two forms of a quiz were developed for the evaluation (see Appendix D). The objectives to be measured by the quiz were:

Table 2.
Number of Classes from Which Data
Was Obtained for Each Instrument

Instrument	Number of Classes (N = 8)
Time record-instructional booklet	8
Time record-problem deck	4
Lesson rating form	8
Interview questionnaire	6
Teacher debriefing questionnaire	8
Teachers booklet (with comments)	0
Teachers problem deck (with comments)	0
Student quiz	7
Student records-problem deck	3
Student work (sample)	0
Classroom observations	0
In-service tape recordings	1 ^a
Instructional module (with comments)	0

^aThis number refers to one tape recording, not the number of classes.

1. Given a table, the students will be able to read the table.
2. Given a table with two categories and the entries in the first column, the student will be able to generate other entries in the table.
3. Given a table with three categories and a random selection of the entries missing, the student will be able to complete the table.
4. Given a problem and told to use a table to solve the problem, the student will correctly a) write the headings for the table, b) complete some entries in the table, and c) solve the problem.

5. Given a problem in which a table could be used to obtain the solution but was not suggested to the student, the student will a) use a table to solve the problem, and b) correctly solve the problem. If a table is used, the student should enter acceptable headings for the table.

The objectives to be measured by the quiz were developed by the evaluation staff at Indiana, not by the module developers. The objectives of the quiz were, for the most part, congruent with the objectives of the module; however, one exception needs to be noted. Objective 3 was not an objective of the module, but since the problem deck contains several three-category tables, this objective was included as one to be measured on the module quiz.

The items written to measure each objective on each form are:

<u>Items - Form A</u>	<u>Objective</u>	<u>Items - Form B</u>
1	1	1
2	2	2
3	3	3
4	4	4
5	5	5

For problem 1, all four parts on form A and three out of four parts on form B are multiple-choice items. The fourth part of number 1, form B, is a completion item. The remaining problems on both forms are ones where the student is required to complete or generate a table. Table 3 shows the criteria and corresponding points that were assigned to the items for the purpose of scoring the quiz.

Table 3
Criteria and Points for Each Item
of the Tables Module Quiz

Item	Criteria	Points
1	Correct answer	1
	Incorrect answer	0
2	All entries are correct	2
	Some entries are correct	1
	No entries are correct	0
3	All entries are correct	2
	Some entries are correct	1
	No entries are correct	0
4	Correct headings	1
	Incorrect headings	0
	All entries correct	2
	Some entries correct	1
	No entries correct	0
	Correct answer	1
5	Incorrect answer	0
	Correct answer	1
	Incorrect answer	0
	Used a table to solve	1
	Did not use a table to solve	0
	There is evidence the student tried to use a table	1
	No evidence of a table	0
	Correct headings	1
	Incorrect headings	0
	No structural error	1
	Structural error (An error in understanding the problem)	0
	No executive error	1
	Executive error (An error in manipulation or calculation)	0

All of the teachers except one gave the quiz to their students after at least three weeks of work with the problem deck. One teacher was ill for an extended period of time and administered the quiz to his students when they had had no work in the problem deck. This will be commented on further in the analysis section of this report. Each teacher randomly distributed the two forms of the quiz to his/her students so that one half completed form A and the other half form B.

c. Data Collection: The first teacher in-service session for this module involved all of the activities described in the "general evaluation design" of the formative evaluations. The data collection outline for the formative evaluations involved three additional in-service sessions for the primary purpose of evaluating the modules. Due to ice storms, the first and second evaluation in-service sessions for this module were cancelled. As a result, the feedback on the booklet and problem deck was obtained during the third session.

It is important to note that the group of teachers (group 11) that field tested this module consisted of only fifth- and sixth-grade teachers and students. No data is available to determine the appropriateness of this module for fourth-grade students.

3. *Analysis and Results*

a. Implementation: The formative evaluation attempted to answer four questions with respect to the implementation of the module:

1. How do the teachers implement the instructional booklet and problem deck?
2. How much time do the teachers spend on the instructional booklet and the problem deck?
3. How many problems at each level of difficulty were selected?

4. What recommendations do the teachers have for implementing the modules in the curriculum?

i. Description of Implementation Procedures. Table 4 shows the implementation procedures used by six of the teachers. In an effort to examine how well the module "fit in" with the teacher's usual instructional mode the teachers were asked to describe their usual instructional mode in mathematics and other areas and compare their usual procedures to their work with the module. It is interesting that many of the teachers changed instructional modes when they began working with the module (e.g., individualized to whole class) and that none of the teachers felt any difficulty with the change. It appears that a variety of ways were used to implement the booklet and all the teachers were pleased with the approach they selected. A variety of ways were also used to implement the problem deck. Most of the teachers did use some form of small-group instruction and homogeneous grouping seems to have worked best. It is also important to note that in most of the classes the students selected their own cards, rather than the teacher assigning the cards.

The format of this module (an instructional booklet followed by a problem deck) is one of several that could be used to teach problem solving strategies and skills. Another format would be to provide the students with carefully selected problems and simply have the students solve a lot of problems. Since the research on problem solving is not conclusive concerning efficacious instructional formats, the teachers were asked whether the instructional booklet was necessary or whether some form of practice with the problem deck would have been sufficient for teaching the students to use tables in problem solving. The teachers' responses to this issue are part of the statements listed under "transition from booklet to deck" in Table 4. The other statements under this heading refer to the issue of

Table 4
Implementation Procedures for the
Booklet and Problem Deck

Teacher number/grade	Usual instructional mode	Booklet	Deck	Transition from booklet to the deck	Comments
08/5	-Math-homogeneous groups of 6-10 -Whole class in other areas	-Whole class	-Students selected teams(2-4) -Usually homogeneous	-Good	-Problem deck is the heart of the module -The mode he used was felt to be the best considering all the ones he tried last year
28/5	-Math-completely individualized -All modes in other areas	-Whole class	-Heterogeneous groups(3-5) -Teacher assigned groups -Selected own cards	-Good -Booklet is needed and first -He needed to review the booklet at times	-He would use homogeneous groups the next time
29/5-6	-Math-completely individualized -All modes in other areas	-Whole class	-Students selected -Tended to be homogeneous -Group membership changed -Selected own cards	-Good -Booklet is needed and first -She needed to review the booklet at times	-Worked well for these students
05/5-6	-Small groups and individualized in all areas	-Whole class for the 1st page, then individual work.	-Student selected groups of 2 -Selected own cards	-Good	-None

Table 4 (cont.)
Implementation Procedures for the
Booklet and Problem Deck

Teacher number/grade	Usual instructional mode	Booklet	Deck	Transition from booklet to the deck	Comments
18/6	-Heterogeneous groups in all areas	-Individual work	-Homogeneous groups of -Teacher selected one member of the group to explain the solution -Students moved at their own rate	-Good -Booklet is a good introduction	-Worked well
24/6	-Individualized in all areas	-Whole class for the first 3 lessons -Some went individually, most remained with the whole class	-Individuals & small groups -Selected own mode	-Booklet made students "willing" to try problems	-None

how well the instructional booklet prepared the student to enter the problem deck. The responses from the teachers indicate that (1) the booklet is needed for instruction in grades 5 and 6 and (2) the booklet adequately prepares the students to enter the problem deck.

ii. Amount of Time. Tables 5 and 6 show the amount of time each teacher spent with the instructional booklet. Almost every lesson was taught in one class session with the mean length of a session around 45 minutes. Although teacher 05 took nearly two class sessions for each lesson, the mean number of minutes he spent on each lesson was less than the mean for all teachers. The fifth- and fifth/sixth-grade teachers spent

approximately the same number of class sessions on each lesson as the sixth-grade teachers but required a greater number of minutes to complete a lesson. This data agrees with the reports of the fifth- and fifth/sixth-grade teachers that they were "pushed" to complete some of the lessons in one class period of "usual" length. Lessons 2 and 3 required the greatest number of class periods and minutes to complete for all of the teachers. Another observation from Tables 5 and 6 is that the number of class periods used for each lesson and the length of each period remained rather constant for each teacher. Other than the two observations that (1) lessons 2 and 3 required the greatest amount of time and (2) fifth-grade teachers had to spend more minutes on each lesson than sixth-grade teachers, the fluctuations in the amount of time spent on the booklet seem to be a function of the individual teacher's style. The data in Tables 5 and 6, together with the teachers' comments, suggests that:

- 1) most of the lessons can be taught in one class period at grades 5 and 6;
- 2) the lessons require on the average 45-50 minutes to complete at grades 5 and 6; and
- 3) lessons 2 and 3 should perhaps be shortened.

Four teachers recorded the amount of time spent on the problem deck. Table 7 shows the reports of these teachers. When the teachers were interviewed concerning the instructional patterns they selected, each teacher was satisfied that his/her approach was successful in his/her classroom. These four teachers each spent around three weeks with the problem deck. Although several teachers commented that they could have used more time to solve problems in the deck, they felt that three weeks

Table 5
Number of Class Sessions
for Each Lesson

Teacher Number	Grade	Lesson						Mean
		1	2	3	4	5	6	
08	5	1	1	1	1	1	1	1.0
28	5	1	1.5	2	1	1	1	1.3
29	5/6	1	1	1	1	1	-	1.0
05	5/6	2	2	2	2	1	1	1.8
01	6	1	1	1	1	1	1	1.0
09	6	1	1	2	1	1	1	1.2
18	6	1	1	1	1	1	1	1.0
24	6	1	1	1	1	-	1	1.0
Mean		1.1	1.2	1.4	1.1	1.0	1.0	1.12

Table 6
Number of Minutes Spent
on Each Lesson

Teacher Number	Grade	Lesson					
		1	2	3	4	5	6
08	5	2 ^a	4	2	2	2	4
28	5	4	3	5	4	4	2
29	5/6	3	4	4	4	4	b
05	5/6	2	4	4	2	2	1
01	6	2	2	2	2	2	2
09	6	4	4	4	2	1	-
18	6	-	4	3	4	4	1
24	6	1	1	1	1	1	-

- ^a
- 1 - less than 35 min.
 - 2 - 35-45 min.
 - 3 - 45-55 min.
 - 4 - 55-65 min.
 - 5 - greater than 65 min.

^b Data was not reported for the empty cells.

was an adequate amount of practice prior to taking the quiz. The data from Table 7 and teacher interviews indicate that the problem-deck was implemented using a variety of instructional patterns and the teachers were pleased with the approaches they selected.

Table 7
The Instructional Patterns/Time
That Four Teachers Spent
With the Problem Deck

Teacher Number	Instructional Pattern/Time
08	The deck was available for 18 days... students worked on cards during "free time."
24	The students used the cards twice a week for three weeks.
28	The deck was used for five consecutive complete periods and two more periods on successive Fridays.
29	The deck was used for four weeks, two or three times per week, for one-half hour each time.

iii. Problem Card Selection. Only three teachers provided a record of the problems that students selected. Table 8 shows that the frequency of cards selected generally decreased as the difficulty increased. This observation is interesting since the students in nearly every class selected their own cards. Class 29 attempted a great many more problems than the other two classes. The section on "effectiveness" will examine whether the number of problems attempted by class 29 compared to the other two classes is reflected in the performance on the module quiz.

Table 8
Total Number of Problems Attempted
at Each Level of Difficulty
for Three Teachers

Difficulty Level	Teacher Number			Total
	08	28	29	
Blue	157	102	309	568
Yellow	89	171	100	360
White	81	33	78	192
Red	45	66	61	172
Green	43	7	32	82
Total	415	379	580	1374

iv. Comments and Recommendations. The data discussed in this section suggests several recommendations related to the implementation of the module:

1. The instructional booklet and the problem deck were implemented in a variety of ways. Every teacher felt that his/her methods were appropriate for his/her students. The recommended teaching procedures given in the teacher's booklet (see pp. 119-120) appear to be one method for using the module. The teacher's booklet might list several other methods that have been used to implement the module.

2. It appears that the booklet can be used in six days (one day per lesson) with most fifth- and sixth-grade students: Lessons 2 and 3 should be shortened. The problem deck was used for approximately three weeks prior to administering the module. All classes, however, did not spend the same amount of time with the problem deck during the three weeks. Although the teachers stated they could have used more time with the deck, they felt that their procedures for implementing the problem deck during the three weeks were adequate preparation for the quiz. The teacher's booklet does not identify a recommended amount of time for the students to work in the deck. Even if there is not a recommended amount of time, some discussion of this point should be included in the teacher's booklet.

3. Most of the students were allowed to select their own cards from the deck. Three teachers reported the card selections with 580, 415, and 379 problems attempted in these classes. The section titled "effectiveness" will consider whether the number of cards attempted is related to the performance in these three classes.

b. Organization and Content: The formative evaluation attempted to answer a variety of questions related to the organization and content of

the module. The following instruments/forms in Appendix D should be examined to identify the questions considered in the evaluation:

- Interview questionnaire
- Teacher debriefing questionnaire
- Action research discussion questions
- Lesson rating form

Appendix D contains a summary of the data obtained from the interviews and discussion sessions. This data, together with the results of the Teacher Debriefing Questionnaire and Lesson Rating Form, indicates that nearly every teacher involved in the field testing of this module was pleased with:

1. the congruency between the objectives and the content of the module,
2. the display and format of the booklet and problem deck, and
3. the mathematical, psychological, and pedagogical appropriateness of the module's content for the grade and ability levels of the students.

Both strengths and weaknesses of the module can be identified from the data. The teachers reported that the major weaknesses of the module were:

1. The module lacks variety in that:
 - a. most of the problems are "constant ratios," and
 - b. there are very few problems of the type where the students are given the problem statement, asked to solve the problem using a table but not given the headings and some of the entries.
2. The booklet does not emphasize for the teacher and student the variety of ways that one can generate the entries in the tables.
3. The module does not explain the difference/relationship between using tables versus using organized lists to solve problems.*

* Prior to using the "tables" modules, these teachers field-tested the Organizing Lists module. The teachers felt that if both modules are to be used by a teacher, a discussion of the difference/relationship between the two modules would be useful.

The first weakness must be examined related to the purpose of this module. The purpose is to introduce students to the use of tables in problem solving and not to provide all of the experiences related to this skill. Since the teachers were unaware of the "introductory" purpose of the module, this first concern of the teachers is not of major importance. It does imply, however, that this module alone cannot be presented to teachers as one that contains all of the skills related to using tables to solve problems.

At the first teacher session the project staff provided a detailed explanation of the module's content. Included in that explanation was a discussion of the variety of ways that can be used to generate the entries in the tables used in the module. During the individual teacher interviews, nearly every teacher commented that they would not have seen the different ways to generate entries if it had not been for the in-service sessions. Moreover, every teacher stated that the teacher's notes were not useful in this respect. This was further evident from the responses on the Lesson Rating Form. The teachers also felt that the module attempted to "show" the students how to generate entries through the use of true-false items but more emphasis was needed. Two of the fifth-grade teachers and the teachers who had some fifth-grade students in their classes felt that fifth-graders had greater difficulty generating entries than sixth-graders. This will be commented on further in the "effectiveness" section of this report.

Group 11 field tested the module titled Organizing Lists three months before using this module. Although all of the teachers felt there were differences and similarities between the types of problems in the two modules, none was able to identify the difference(s)/relationship.

Since the developers feel that the heart of the module is the problem deck, the patterns in problem card selections are of particular interest.

Tables 9, 10, and 11 were developed for this purpose. The following observations seem the most salient with respect to the problem card selections. (Note: The data in these tables is the result of feedback from only three teachers.)

Table 9
Total Number of Problems
Attempted for Each Problem Type at
Each Difficulty Level^a

Difficulty Level	Problem Type					Total
	C	S	M	B	R	
Blue	239(9) ^b	129(8)	167(10)	5(2)	29(4)	568(33)
Yellow	101(10)	77(6)	108(9)	41(3)	33(6)	360(34)
White	30(6)	64(12)	13(1)	49(6)	36(12)	192(37)
Red	25(4)	15(4)	52(5)	58(10)	22(6)	172(29)
Green	18(6)	16(6)	11(3)	33(5)	4(3)	82(23)
Total	412(35)	301(36)	351(28)	186(26)	124(31)	1374(156)

^a N = 3

^b (9) cards of this type and difficulty level are in the deck.

Table 9

1. The "reading" (R-type) problems were tried on the average by the fewest number of students. The quiz results to be discussed in the next section show that around ninety-five percent of the students were able to read tables.

2. The S- and B-type problems were attempted fewer times than the C- and M-type problems. Although the S-, B-, C-, and M-type problems all require the student to complete a table, the S- and B-type problems ask the student a question (B-type) or questions (S-type). Perhaps a question(s)

on the card led the students to select these types of problems less frequently.

Table 10
Percent of Total Number of Problems Attempted
for Each Problem Type and Difficulty Level

Difficulty Level	Problem Type					Total
	C	S	M	B	R	
Blue	17(6) ^a	9(5)	12(6)	<1(1)	2(3)	40.5(21)
Yellow	7(6)	6(4)	8(6)	3(2)	2(4)	26(20)
White	2(4)	5(8)	1(1)	4(4)	3(8)	15(25)
Red	2(3)	1(3)	4(2)	4(6)	2(4)	13(19)
Green	1(4)	1(4)	1(1)	2(3)	<1(2)	5.5(15)
Total	29(23)	22(24)	26(16)	13.5(16)	9.5(21)	100(100)

^a (6) percent of the total number of cards in the deck are of this type at this level of difficulty.

Table 10

3. Twenty-one percent of all cards were R-type problems while only 9.5 percent of all problems attempted were this type. The teacher interviews revealed that these problems were good for motivation but reading tables was not a new skill for the students in these classes.

4. Nearly 30 percent of all the problems selected were type C with 17 percent of the 30 from the blue difficulty level. Nine blue cards were C-type with seven of the nine located in the first third of the blue problems. Although most students selected their own cards, the data on the individual problems indicates that the students selected most of the problems from the first third in each difficulty level. The large percentage of C-type (and blue-C-type) problems selected may be due to the location of the cards in the deck rather than to some other character-

istic of the problems.

Table 11
Percent of Students that Rated Problems as
Hard and Disliked at Each Level of
Difficulty and Problem Type for Three Teachers

Difficulty Level	Problem Type					Total
	C	S	M	B	R	
Blue	9,13 ^a	8,12	2, 6	0,20	7,11	7,11
Yellow	29,23	18,17	10,12	5,15	12, 3	17,16
White	13,13	8, 8	0, 8	6,10	3,11	7,10
Red	16,16	7, 7	15,15	22,22	18,18	17,17
Green	33,22	38,25	27,27	40,30	25,25	35,27
Total	16,16	12,13	7,10	17,19	10,14	12,14

^a The percents for "Easy" and "Liked" can be found by subtracting each number from 100 respectively.

Table 11

5. For all the problems attempted, nearly 90 percent were rated by the students as "easy" and "liked."
6. The yellow type C, S, and M problems appear to be rather difficult.
7. Within the green problems, which were considered to be the most difficult, the S- and B-type problems were rated the hardest. (These types are characterized by the use of questions.)
8. For all problems, the C-, S-, and B-type problems were noted as the hardest. Although the S- and B-type problems are characterized by the use of questions, many of the C-type problems also contain questions.
9. The C-type problems were consistently rated the hardest for all difficulty levels save level green.

The data discussed in this section suggests the following recommendations related to the organization and content of the module:

Instructional Booklet

1. The "introductory" nature of this module should be discussed in the teacher's edition and perhaps mentioned in the title of the module.
2. The role of "tables" in problem solving should be explained to the teachers in the teacher's edition.
3. If teachers are to use this module without the aid of in-service education, the teacher's notes should provide a detailed presentation of the mathematics in the module.
4. The instructional booklet should provide additional emphasis related to the variety of ways to generate entries in tables. Implementing recommendation 3 could alleviate the weakness that motivated this recommendation and/or additional material could be provided in the student booklet.

Problem Deck

5. The quantity of reading (R)-type problems should be reduced and/or the difficulty of these problems should be increased for fifth and sixth grade students (see p. 140 for a further discussion of this recommendation).
6. The C-type problems at the blue difficulty level should be more evenly distributed among the set of blue problems.
7. The yellow type C, S, and B problems should be examined for their location in the deck. Some of these problems should be moved to a higher difficulty level.
8. The distinctions between all the problem types should be discussed in the teacher's booklet. Particular attention should be given to the distinction/similarity between the C- and B-type problems.

9. Relatively high percentages on "hard" and/or "dislike" suggest that the following problems be examined: blue - 8, 19, 20; yellow - 1, 16; red - 2, 3; green - 1.

10. The alphameric code on the problem cards should be explained in the teacher's booklet.

c. Effectiveness: The two previous sections concerned implementation and organization and content of the module. This section will be primarily concerned with the data from the module quiz related to student performance.

i. Teacher judgment. Data from the in-service session and the teacher interviews provide some evidence related to the effectiveness of the module. Some of the teachers' comments are:

- This is the best module we've used. (four teachers)
- The students had good attitudes. (six teachers)
- Some carry-over was noticed in other areas. (two teachers)

At some point during the evaluation activities every teacher commented that his/her students had attained the objectives of this module. Also, nearly every teacher stated that students of all ability levels were able to find some success with this module.

ii. Quiz results. In order to provide additional evidence of whether the students did attain the objectives of the module, the quiz results will first be analyzed and discussed related to each objective.

The objectives of the quiz were developed by the evaluation staff through examining the activities in the instructional booklet and the types of problems in the problem deck. As a result, the quiz results can be analyzed with respect to the content of the booklet and the problem deck.

Table 12 shows the results of the module quiz for each form and at each grade level. A specific criterion level for successful performance was not established. Rather, the quiz results were examined for any trends that suggested changes in the module. The five objectives to be measured by the quiz are given on pages 121-122. The quiz results suggest the following related to these objectives.

Objective 1: Nearly every student (93%) was able to correctly read a table. This data, together with the fact that very few students selected the R-type problems in the deck, suggests that the "reading" problems may be rather easy for most fifth- and sixth-grade students. Several teachers commented that reading tables was not a new skill for fifth- and sixth-grade students. However, they did feel that the lesson on reading tables was useful for motivation. Also, it is possible that the high performance on problems concerned with reading a table is the result of their prior experiences with the lessons related to completing tables. That is, the skill of reading a table may be developed as the student has experiences with completing tables.

Objective 2: The problems related to this objective require the student to complete a table with two categories. The problems related to objective 4 also require the student to complete a table with two categories. On all of the problems related to these two objectives, when the criterion is "correctly completing some of the entries," 80 percent of the students met the criterion. This level of success may perhaps be attributed to the large number of problems in the deck that were attempted where the student was (at least) asked to complete a two-category table. Except for the "reading problems" and 10 problems that have three

Table 12

Quiz Results: Form A

Problem No.	Criteria ^a	Maximum ^b	5th Grade Mean (N=41)	6th Grade Mean (N=54)
1(1)	- ^c	1	.89	.94
1(2)	-	1	.89	.94
1(3)	-	1	.91	.96
1(4)	-	1	.93	.98
2	correct entries	2	1.53	1.61
3	1st entry correct	1	.73	.77
	2nd entry correct	1	.66	.69
	3rd entry correct	1	.60	.63
	all entries correct	2	1.31	1.38
4	correct headings	1	.86	.91
	correct entries	2	1.56	1.64
	correct answer	1	.60	.63
5	used a table	1	.47	.50
	evidence of a table	1	.64	.67
	correct headings	1	.42	.44
	no structural error	1	.91	.91
	no executive error	1	.94	.94
	correct answer	1	.58	.61

^a See p. 123 for details of the quiz criteria.

^b Maximum refers to the total number of points possible on that item.

^c For these problems, only the final answer was examined.

(continued)

Table 12 (Continued)

Quiz Results: Form B				
Problem No.	Criteria ^a	Maximum ^b	5th Grade Mean (N=40)	6th Grade Mean (N=53)
1(1)	-	1	.91	.98
1(2)	-	1	.91	.98
1(3)	-	1	.90	.97
1(4)	selected 12	1	.88	.95
	selected 2	1	.88	.95
	selected 4	1	.86	.92
	selected 6	1	.87	.94
2	correct entries	2	1.58	1.70
3	1st entry correct	1	.71	.76
	2nd entry correct	1	.68	.73
	3rd entry correct	1	.67	.72
	4th entry correct	1	.69	.74
	all entries correct	2	1.30	1.40
4	correct headings	1	.87	.94
	correct entries	2	1.52	1.63
	correct answer	1	.63	.68
5	used a table	1	.27	.29
	evidence of a table	1	.32	.34
	correct headings	1	.23	.25
	no structural error	1	.92	.91
	no executive error	1	.78	.76
	correct answer	1	.35	.38

^a See p. 123 for details of the quiz criteria.

^b Maximum refers to the total number of points possible on that item.

^c For these problems, only the final answer was examined.

categories, all of the problems in the deck involve completing two-category tables.

Objective 3: The problems related to this objective also ask the student to complete a table but now the table has three categories. Sixty-seven percent of the students correctly completed some of the entries. It is interesting that only 67 percent were able to complete the tables in the problems related to objective three while 80 percent were successful in the problems related to objectives two and four. Only ten problems in the problem deck ask the student to complete a table that has three categories. Also, only six percent of the problems attempted were this type. It appears that the ability to complete two-category tables does not necessarily make one effective at completing three-category tables. The teachers that have fifth- and sixth-grade students remarked that the fifth-graders had more difficulty completing the three-category tables than the sixth-graders. This remark is not supported by the quiz results since approximately 67 percent at each grade level correctly completed the tables. It is important to note that the objective of completing three-category tables was not an objective of the module but was included by the evaluation staff as an objective to be measured by the quiz since several problems in the problem deck involve three-category tables.

Objective 4: One of the criteria established for the problems related to this objective was the same as that discussed for objective two; that is, "the student will correctly complete some of the entries." The results related to this criterion are discussed above. The additional criteria for these problems on the quiz

were that the students would (a) enter acceptable titles for the categories and (b) obtain the correct answer to the question(s). Nearly 100 percent were able to identify appropriate headings for the tables. The problems related to objective five also required the student to enter titles for the categories in the tables. In the problems related to objective five, nearly 90 percent entered acceptable titles. Only three problems in the booklet and 15 (10%) problems in the deck require the student to select titles for the categories. It appears that even though the module does not provide a great deal of practice at identifying titles, the students were successful at this task with the problems related to objectives four and five.

When the correct answer is used as the criterion, 66 percent of the sixth-graders and 62 percent of the fifth-graders correctly solved the problem. Recall that the data on problem card selections shows that the problems where the student is asked to answer a question using a table (types B and S primarily) were rated more difficult than the problems where they are not asked a question.

Objective 5: For the problems related to this objective the students were not given the framework for a table nor were they told to use a table to solve the problem. Table 13 shows that 39 percent of the students used a table to obtain an answer while 27 percent used a table to get a correct answer. Sixty-nine percent of those that did use a table did get the correct answer while only 36 percent of those who did not use a table found the correct solution. Most of the classes scored below 50 percent when the criterion is the correct answer.*

* This, of course, may be due to the difficulty of the problems on the quiz.

Teacher 24's students performed considerably higher than the other classes. This teacher did not record the problem card selections but did report that the students used the cards twice a week for three weeks. Teacher 24's implementation procedures for the booklet and the students' characteristics (e.g., ability levels, socioeconomic background) were similar to the other teachers and as a result do not appear to be the reason for such a high performance.

Although only 49 percent of the students obtained the correct solution to the two problems related to objective five, the performance on problem five on form A was considerably higher than the performance on problem five on form B, 60 percent versus 37 percent (See Table 12). Also, 49 percent of the students used a table to solve problem five, form A, while only 28 percent used a table on form B.

Table 13

Percent of Students That Used Tables for the Problems Related to Objective Five

Teacher	Grade	Number of Students	Used Table ^a	Used a Table and got the Right Answer	Relative Percent ^a	Correct Answer
28	5	28	60(44,16) ^b	36(32,4)	60(73,25)	40(32,
08	5	28	8(8,0)	4(4,0)	50(50,0)	36(20,
05	5/6	25	44(28,16)	36(24,12)	82(86,75)	52(28,
29	5/6	30	29(23,6)	12(6,6)	41(26,100)	45(32,
01	6	27	44(37,7)	26(22,4)	59(59,57)	41(26,
09	6	26	29(13,16)	17(13,4)	59(100,25)	46(38,
24	6	32	60(32,28)	55(32,23)	92(100,82)	81(39,
Mean			39(26,13)	27(19,8)	69(23,62)	49(31,

^a Percent who used a table and got the right answer divided by the percent who used a table.

^b The first number indicates the percent for form A and the second number the percent for form B.

iii. Summary - objectives one through five. For the fifth- and sixth-grade students in this field test, nearly every student was able to read a table. Most students (80%) were able to generate some entries in two-category tables. Fewer students (67%) were able to generate some entries in three-category tables. The students in most cases were able to identify appropriate headings for a table. Approximately 50 percent of the students obtained a correct solution to the problems related to objectives four and five; however, the performance was considerably higher on form A (60%) than on form B (37%).

iv. Further analyses. Two additional analyses are possible with the quiz results. First, the data provided by three teachers with respect to problem card selections will be examined for a relationship between the number of cards that were attempted and the performance on the quiz. Next, one teacher's class was administered the module quiz without having any experiences with the problem deck. This class's quiz results will be compared to the mean scores for all the students.

Table 8 on page 131 shows the number of problems attempted for three teachers. The students in class 29 attempted 580 problems while 415 and 379 were attempted in the others. Table 14 shows that the performance of class 29 was greater than or equal to both of the other classes for five of the eight categories. Since most of the problems in the deck ask the student to complete two-category tables and class 29 attempted the most problems in the deck, it follows that class 29 attempted more problems of this type. Problem number two asks the student to complete a two-category table and Table 14 shows that class 29 performed considerably higher than the others. This

Table 14
Quiz Results on the First Four
Problems for Three Teachers

Teacher	1(1-3) ^a	1(A4) ^b	1(B4)	Problem Number				
				2	3	4A ^c	4B	4C
29	99	100	87	82	58	84	67	52
28	92	92	90	64	52	80	68	52
08	89	92	83	64	58	96	74	52

^a Entries in this column represent the mean percent of correct answers for problem 1, part 1-3, on both forms.

^b 1(A4) and 1(B4) indicate the 4th part of number 1, forms A and B respectively.

^c 4A - Acceptable titles were entered.
4B - Some entries were correctly completed.
4C - correct solution

trend was not present in problem four (4B); however, the performance scores for all three groups are nearly the same. When the correct solution is the criterion, class 29 performed equally well for problem number four. Also, Table 13 shows that class 29 had a higher percentage of correct solutions than classes 28 and 08 on problems five. The evidence in Tables 13 and 14 shows that for these three teachers the class that attempted more problems in the deck generally performed higher than the other two. For the eight categories in Table 14 it is interesting that the scores for class 29 are higher than the mean scores for all students on only three categories. Class 29 is primarily a fifth-grade class and classes 28 and 08 are completely fifth grade. The grand means were calculated with fifth- and sixth-grade classes and the sixth-graders generally scored higher than the fifth-graders, especially the sixth-graders in class 24. Therefore, it appears that among the fifth-graders, the students that attempted the most problems in the deck generally performed higher than the students that attempted

fewer problems. Class 05 contains fifth-graders and generally performed higher than class 29. However, only approximately 30 percent of the students in class 05 are fifth-graders while over 50 percent are fifth-graders in class 29.

Teacher 09 was ill for an extended period of time. As a result, the students in his class did not work at all with the problem deck before the module quiz was administered. Table 15 shows that the mean performance of the students in class 09 was higher than the mean for all students on seven of the eight categories. However, when the students in class 09 are compared to other sixth-graders (Table 16), the mean performance is higher on only three of the categories and by only one percentage point in each. For the categories in which the mean for the students in class 09 is less than the mean for all sixth-graders, the mean difference is six percentage points. Therefore it appears that among the sixth-graders, those students that attempted the problems in the deck generally performed higher than those students who did not attempt any of the problems.

Table 15
Quiz Results for One Teacher Who Did
Not Work with the Problem Deck

Teacher	Problem Number							
	1(1-3) ^a	1(A4) ^b	1(B4)	2	3	4A ^c	4B	4C
09	99	100	98	94	81	92	81	63
Grand Mean for Teachers	93	96	91	81	67	90	79	64

^a Entries in this column represent the mean percent of correct answers for problem 1, part 1-3, on both forms.

^b 1(A4) and 1(B4) indicate the 4th part of number 1, forms A and B respectively.

^c 4A - Acceptable titles were entered.
4B - Some entries were correctly completed.
4C - correct solution

Table 16
Quiz Results for Classes with
Sixth-Grade Students

Teacher	Problem Number						
	1(1-3)	1(A4)	1(B4)	2	4A	4B	4C
05	96	100	100	95	99	91	81
01	99	100	100	98	100	98	74
24	97	100	100	83	100	94	84
09	99	100	98	94	92	81	63
Mean	98	100	100	93	97	91	76

v. Summary of effectiveness. This section of the evaluation was primarily concerned with the students' performance on the module quiz. It is important to mention again that this module is part one of a two-module sequence. Some of the comments below might no longer apply if the second half of the sequence were developed.

1. There is some evidence to suggest that the module may have had a positive effect on many areas (e.g., attitudes, ability to solve problems using tables, etc.) (see p. 139).
2. "Reading tables" may not be a new skill for the fifth- and sixth-graders (see p. 140).
3. Most students were able to complete some entries in the two-category tables. The three-category tables were more difficult.
4. Most students were able to identify appropriate titles for the categories of a table.
5. Most students did not use a table to solve problems when the use of a table was not suggested.* However, the percentage of students

* The "use of a table" was determined by examining students' work on the quiz. It is possible that students used tables but did not draw the table on the quiz form.

that obtained the correct solution was higher among the students that did use tables than among the students that did not. This suggests that the use of a table did help the students to find the correct solutions to the problems on the quiz.

6. There is evidence that at grade five the students that attempted the most problems in the deck performed best on the quiz. Also, there is evidence that at grade six the students that attempted some problems in the deck performed better than the students that did not attempt any problems in the deck. This suggests that attempting the problems in the deck did have a positive effect on the performance on the quiz.

4. *Summary and Recommendations*

The formative evaluation of Using Tables to Solve Problems was conducted under the general design of the formative evaluation given in Chapter A of this report. Data was collected concerning the three major questions of the formative evaluations related to the implementation, organization and content, and effectiveness of the module. This section will summarize the results of the evaluation related to each of the major questions.

a. Implementation:

1. The instructional booklet and the problem deck were implemented in a variety of ways. Every teacher felt that his/her methods were appropriate for his/her students. The recommended teaching procedures given in the teachers' booklet (see p. 119-120) appear to be one method for using the module. The teacher's booklet should list several of the methods that have been used to implement the module.

2. It appears that the booklet can be used in six days (one day per lesson) with most fifth- and sixth-grade students. Lessons 2 and 3 should be shortened. The problem deck was used for approximately three weeks prior to administering the module quiz. All classes, however, did not spend the same amount of time with the problem deck during the three weeks. Although the teachers stated they could have used more time with the deck, they felt that their procedures for implementing the problem deck for three weeks were adequate preparation for the quiz. The teacher's booklet does not identify a recommended amount of time for the students to work in the deck. Even if there is not a recommended amount of time, some discussion of this point should be included in the teacher's booklet.*
3. Most of the students were allowed to select their own cards from the deck. Three teachers reported the card selections with 580, 415, and 379 problems attempted in these classes. The results on the module quiz show that the class that attempted the most problems generally performed better on the quiz. The module developers have not identified a number of problems that should be attempted at each difficulty level by students of different ability levels. Even if such a number is not to be identified, some discussion should be provided related to the findings of this evaluation concerning the relationship between performance and problem card selections.*

* This issue is discussed in the revised teacher's module developed as a result of this report.

b. Organization and content:

4. The "introductory" nature of this module and the role of "tables" in mathematical problem solving should be discussed in the teacher's booklet.
5. The teachers had difficulty identifying the variety of ways one can generate the entries in the tables. If teachers are to use this module without the aid of in-service education, the teacher's notes should provide a detailed presentation of the mathematics in the module.
6. The distinctions between all the problem types should be discussed in the teacher's booklet.
7. Specific organization and content recommendations are included in the section titled "Organization and Content" and in Appendix D.

c. Effectiveness: The section related to the "effectiveness" of this module was primarily concerned with the students' performance on the module quiz. The following comments are related to the effectiveness of the module.

8. Most students were able to complete some entries in the two-category tables. The three-category tables were more difficult.
9. Most students did not use a table (i.e., draw a table) to solve a problem when the use of a table was not suggested. The quiz results indicate that the percent of students that obtained the correct solution was higher among the students that did use tables than among the students that did not.

The teacher feedback and the results of the module quiz provide evidence of the "introductory" nature of the objectives of this module. The development of the second part of this module would be a real contribution to its potential effectiveness.

APPENDICES TO
TECHNICAL REPORT III: MODULE DEVELOPMENT AND
FORMATIVE EVALUATION

- APPENDIX A: Evaluation Instruments and Forms
- APPENDIX B: Organizing Lists Quizzes and Data
- APPENDIX C: Using Guesses to Solve Problems Quizzes and Data
- APPENDIX D: Using Tables to Solve Problems Quizzes and Data

(Appendices Under Separate Cover).